Neutrino Detector operated in space.

What new science can be done, how can we do it with an unshielded detector.

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Neutrino Intensity can change dramatically with distance from the Sun as $1/r^2$.

at 7 solar radii where NASA Parker Space probe currently orbits that is 1000x more than on Earth

at 3 solar radii where NASA thinks it can work that would be 10,000x more neutrinos than at Earth.

Table 1: Intensity of solar neutrinos at various distances from the Sun.

Distance from Sun	Solar Neutrino intensity relative to Earth
696342 km	46400
1500000 km (~3 Sun R)	10000
4700000 km (~7 Sun R)	1000
15000000 km	100
474340000 km	10
Mercury	6.7
Venus	1.9
Earth	1
Mars	0.4
Astroid belt	0.1
Jupiter	0.037
Saturn	0.011
Uranus	0.0027
Neptune	0.00111
Pluto	0.00064
KBP	0.0002
Voyager 1 probe 2015	0.00006

Unique Science with Neutrino Space Detector.

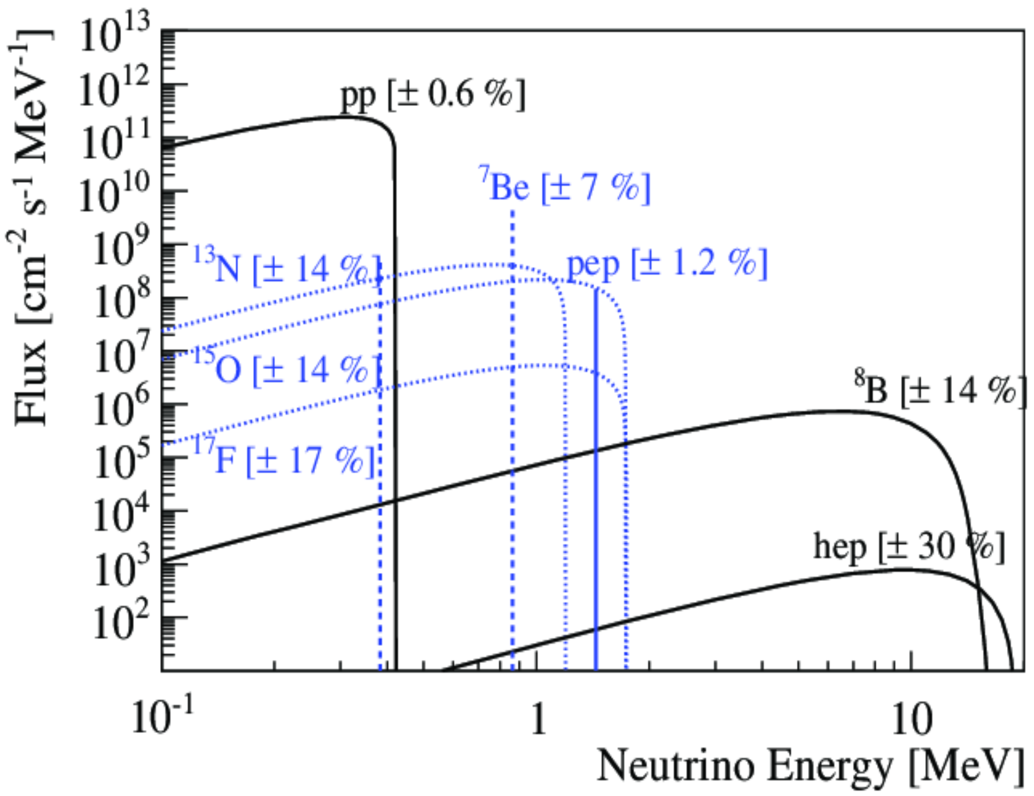
Heliophysics

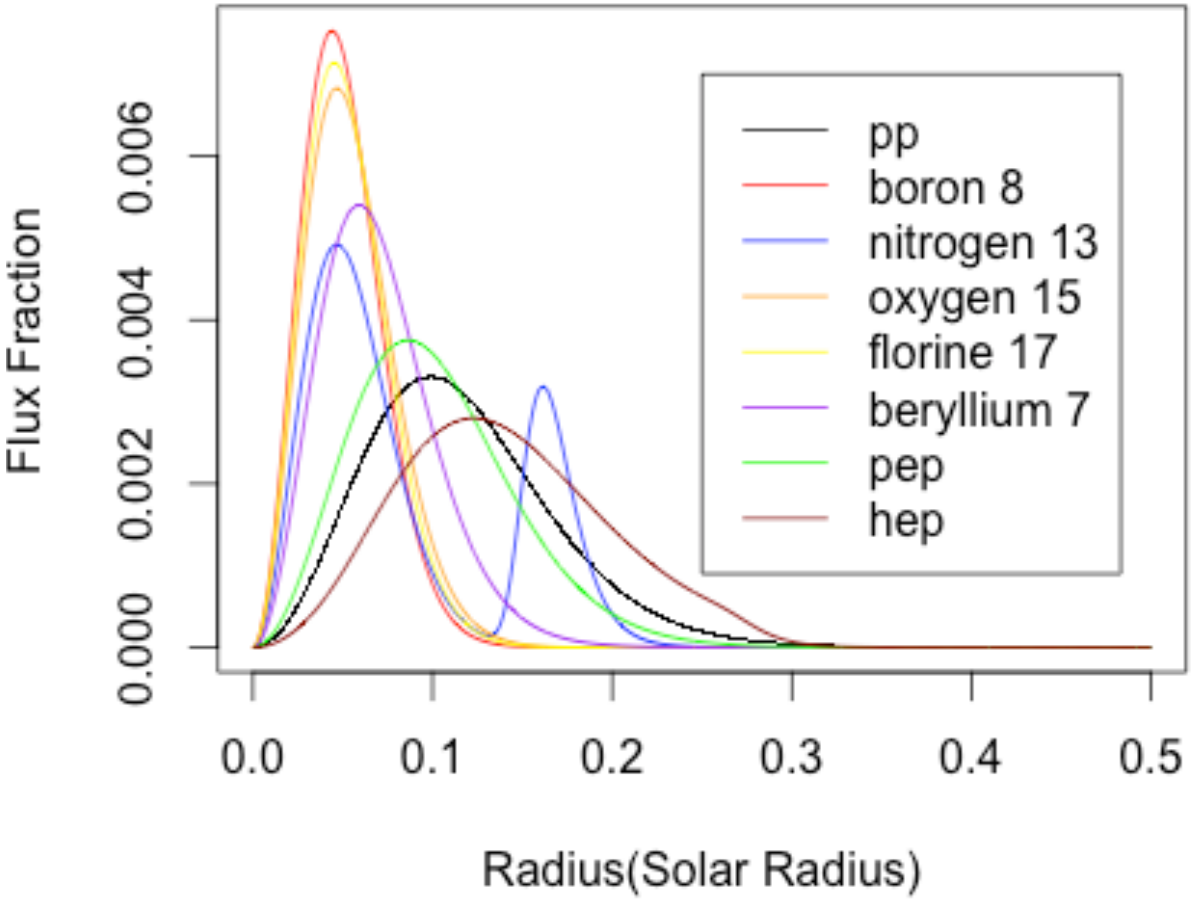
1. Closer to Sun for rare fusion neutrinos
2. Off the ecliptic plan for polar orbit view
3. Measure size of fusion core
4. Dark matter trapped in core of Sun displacing fusion

Particle Physics

1. Observe electron neutrino disappearance vs distance as space craft enters and leaves coherent/de-coherent transition.

Solar Fusion and location using Solar Model



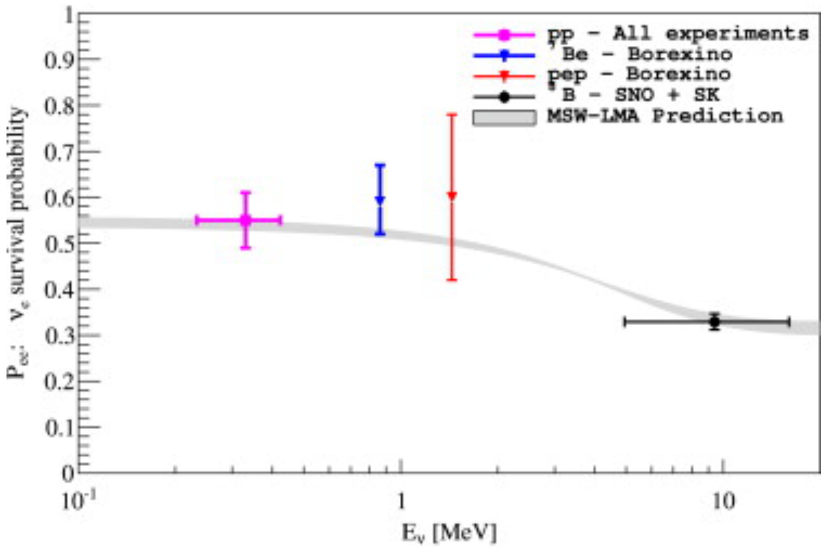


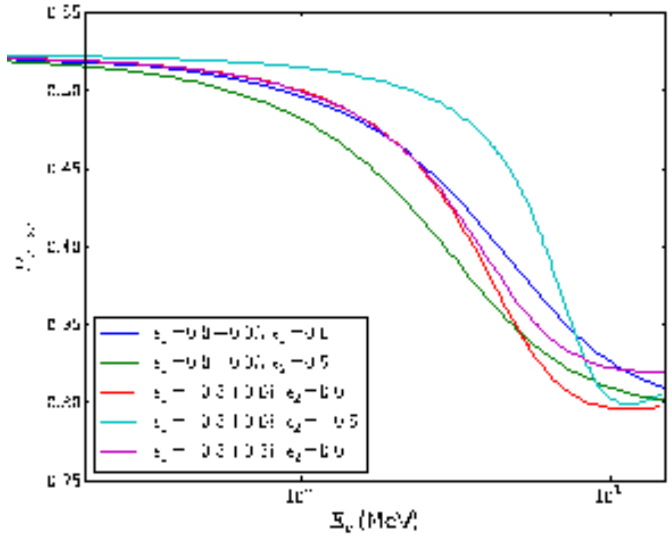
Study Solar Nuclear Core:

- By going close to the Sun it not only increases the neutrino flux and improves the signal to noise ratio, but allows a platform for new Science studying neutrino transition between coherent and de-coherent.

- Science:
  - Rare neutrino fusion and better understand of current fusion neutrino processes.
  - At Earth the neutrino oscillations are coherent, but closer than 35 solar radii solar neutrino flavors are incoherent, changing their ratio to each other with distance from the sources

Neutrino Energy (MeV)	Oscillation length (km)	Coherence Length (km)	[illegible]$_x$ (cm)
1	34	2.44x10^{5}	3.15x10^{-9}
5	170	6.10x10^{6}	3.15x10^{-9}
10	340	2.44x10^{7}	3.15x10^{-9}

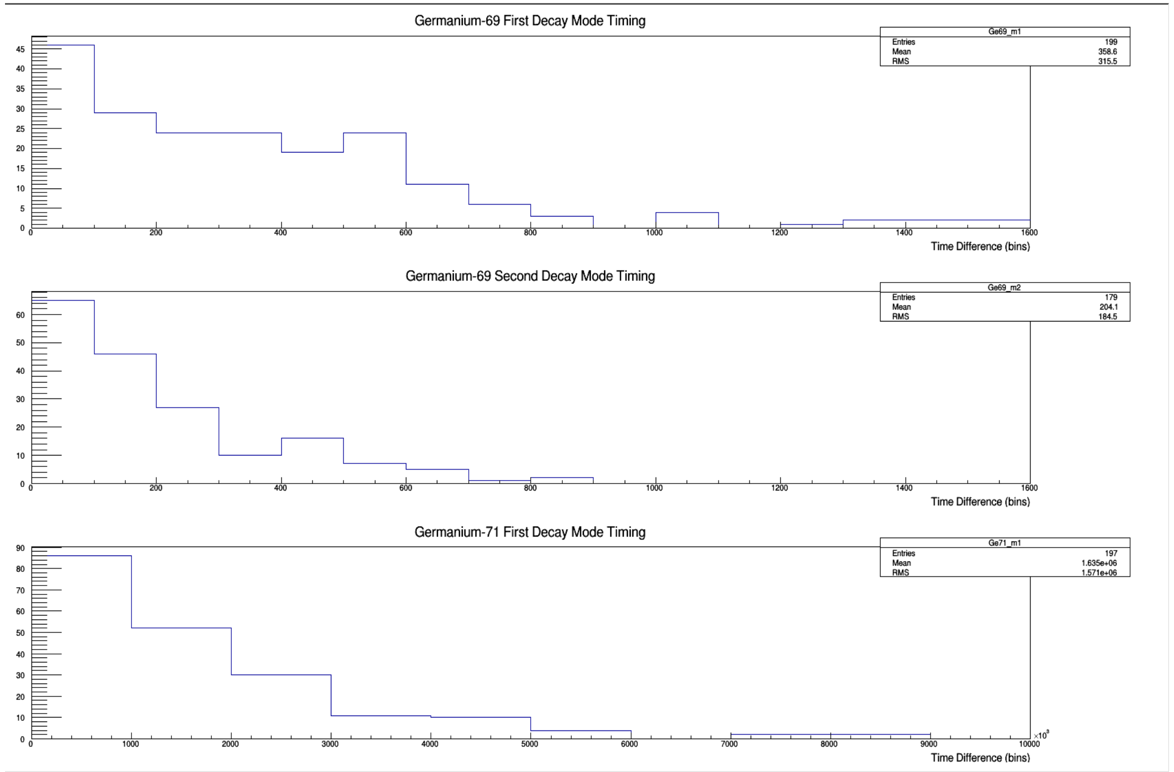




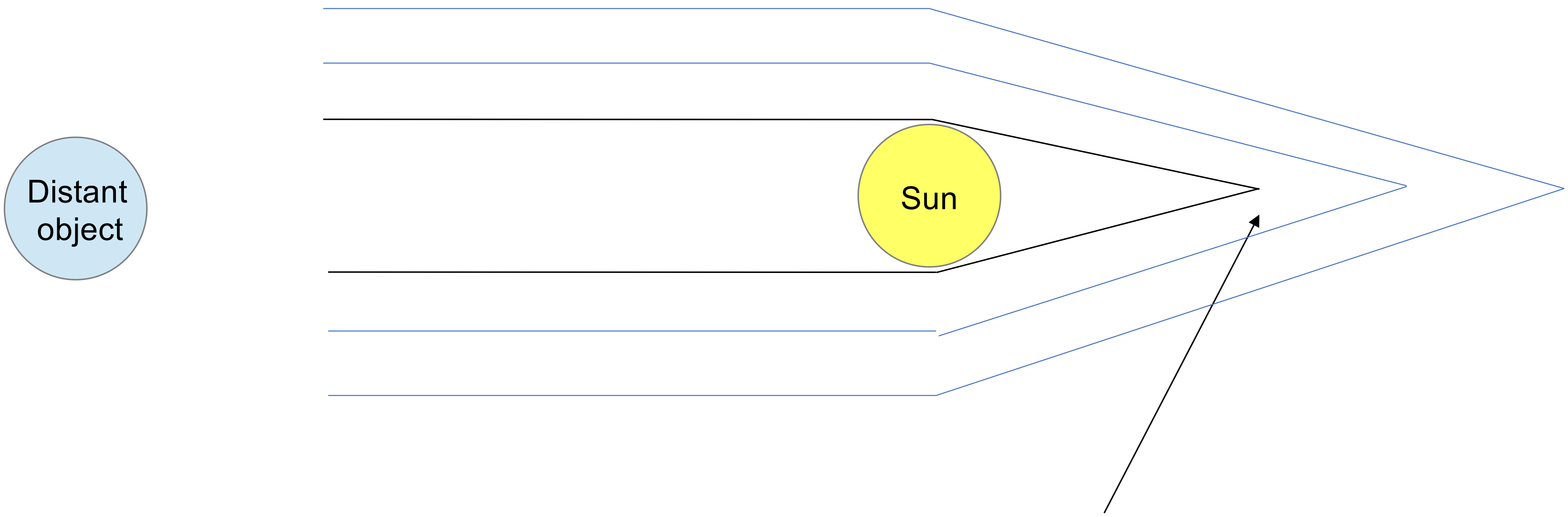
A double delayed coincidence can operate unshielded in space.

$^{69}Ga + \nu$ into e- ^{69}Ge m1 or m2	^{69}Ge m1 decays X-ray	5 us	86 keV
	^{69}Ge m2 decay gamma	2.8 us	397 keV
$^{71}Ga + \nu$ into e- ^{71}Ge m1	^{71}Ge m1 decay gama	20 ms	175 keV

Monte-Carlo simulation of neutrino interaction, galactic cosmic and gamma ray backgrounds mixed with proper ratio and then reconstructed looking for double delayed coincidence with 2nd pulse having a signature energy. This had 10% fake events and the reconstruction shows expected half-life decay curve.



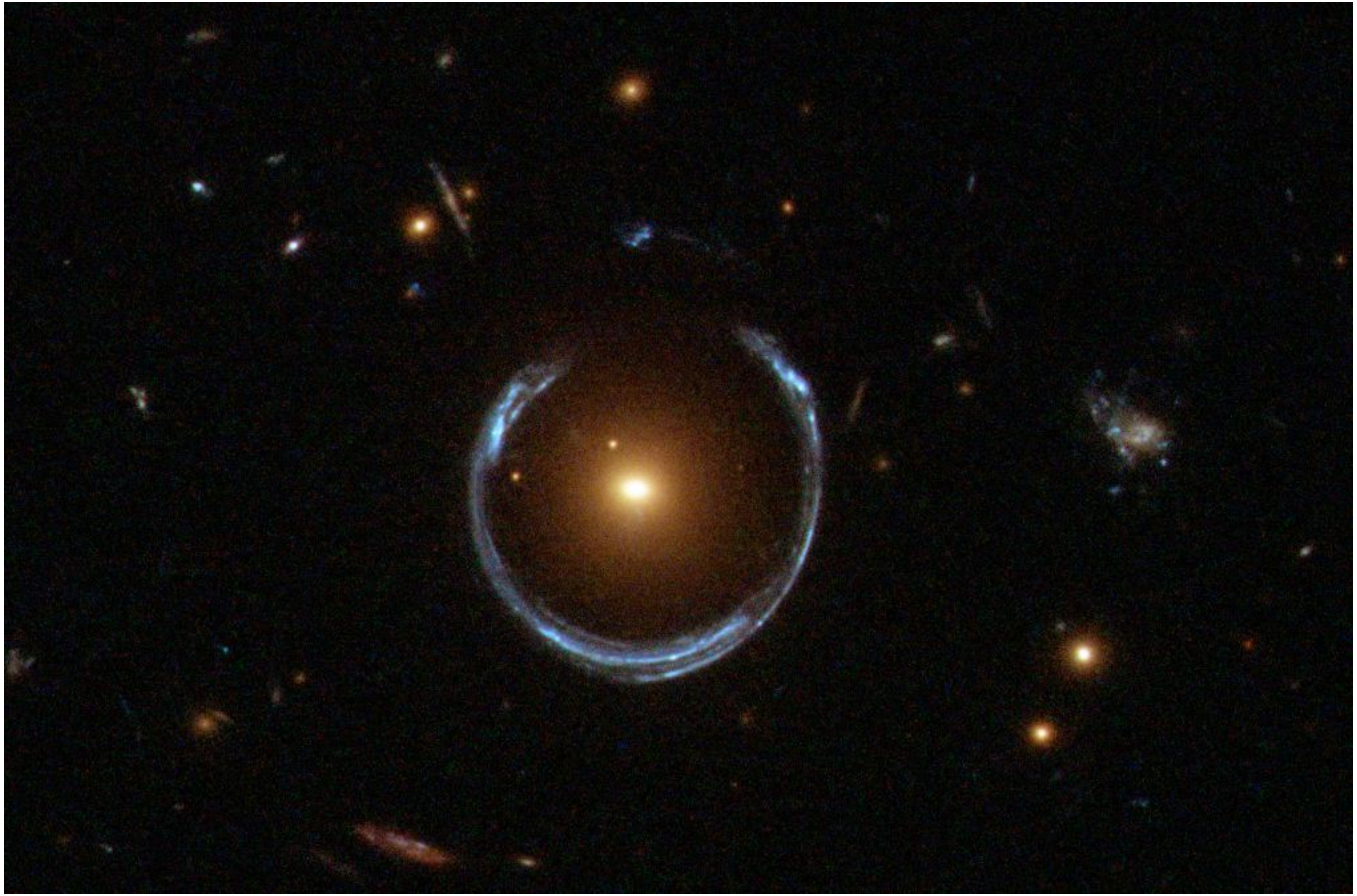
Gravitational Lensing of Galactic Core



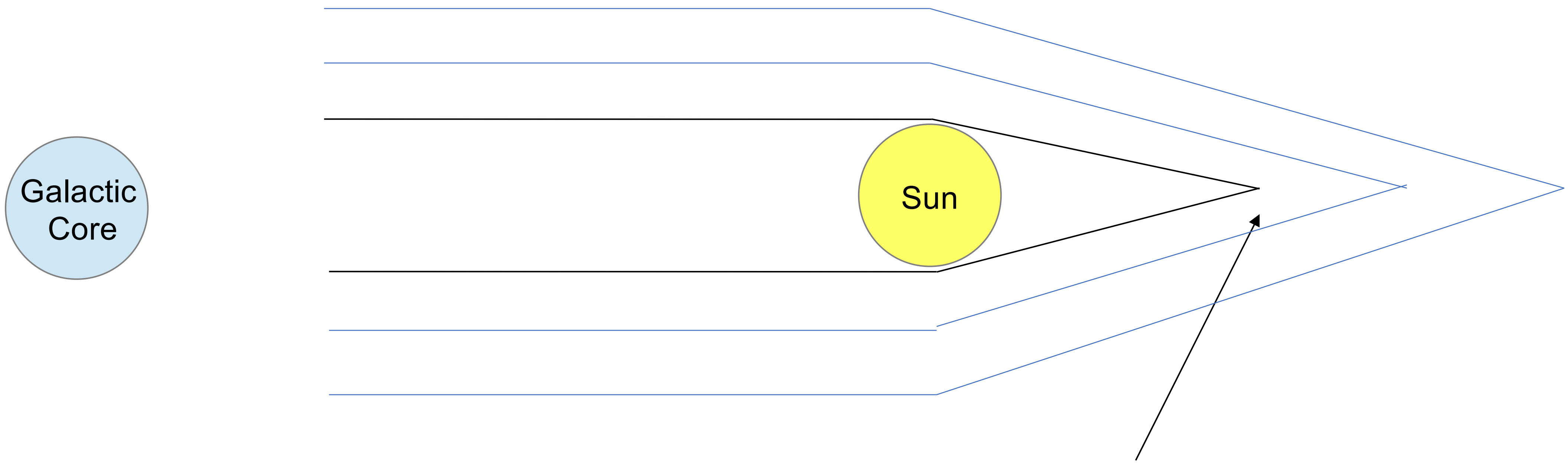
For Light the gravitational focus is 550 to 700 AU.

[1] A. Einstein, Lens-Like Action of a Star by the Deviation of Light in the Gravitational Field, Science, Vol. 84 (1936), p. 506.
[2] M. J. Dulude et al., WFC3 HST STSI Instrument Science Report, 2011-04, Feb. 2011.
[3] G.A. Landis, Mission to the Gravitational Focus of the Sun: A Critical Analysis, 23 April 2016, arXiv:1604.06351v2 [astro-ph.EP].
[4] S.G. Turyshev and B-G. Andersson, “The 550-AU Mission: a critical discussion”, Mon. Not. R. Astron. Soc. 341, pp. 577-582 (2003).

Hubble has some nice images of accidental alignment:



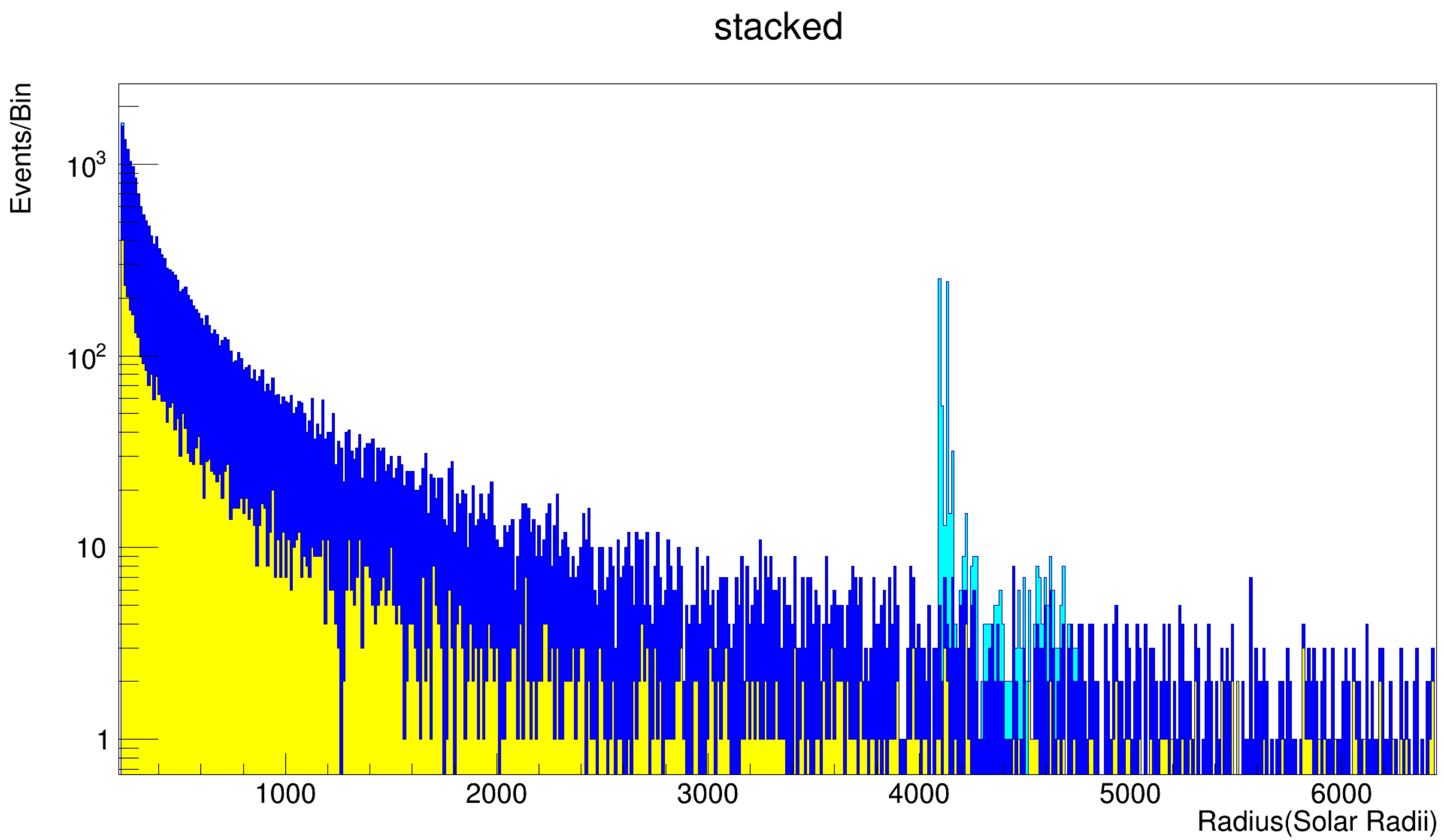
Gravitational Lensing



Neutrinos have mass their Neutrino Gravitational Focus is much closer, 20 to 45 AU.
Rough estimate is 800x to 8000x solar neutrino rate at Earth for Stellar Galactic core.

Y. Demkov and A. Puchkov, Gravitational focusing of cosmic neutrinos by the solar interior, Phys. Rev. D v61, 083001.

Using the 2nd brightest neutrino source in sky, the galactic core and Neutrino Grava tonal Focus here is a simulation of 500 kg neutrino detector as it moves away from Earth opposite the galactic core.



Science goals:

Image galactic core in neutrinos, stellar fusion and high energy accretion disks.

Use the location of neutrino gravitational focus to measure mass of electron neutrino.

Conclusion:

- There is unique new science that can be done
  - Close to Sun to better understand Heliophysics
  - Particle physics of coherent/de-coherent transition
  - Dark matter in core of Sun
  - At galactic focus of the Neutrino Gradational Focus
- A detection method was developed and lab tests are under way